



## Electronics/Computers

### Microwave Power Combiners for Signals of Arbitrary Amplitude

Output polarization would no longer vary with input amplitudes.

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Schemes for combining power from coherent microwave sources of arbitrary (unequal or equal) amplitude have been proposed. Most prior microwave-power-combining schemes are limited to sources of equal amplitude.

The basic principle of the schemes now proposed is to use quasi-optical components to manipulate the polarizations and phases of two arbitrary-amplitude input signals in such a way as to combine them into one output signal having a specified, fixed polarization. To combine power from more than two sources, one could use multiple power-combining stages based on this principle, feeding the outputs of lower-power stages as inputs to higher-power stages.

Quasi-optical components suitable for implementing these schemes include grids of parallel wires, vane polarizers, and a variety of waveguide structures. For the sake of brevity, the remainder of

this article illustrates the basic principle by focusing on one scheme in which a wire grid and two vane polarizers would be used.

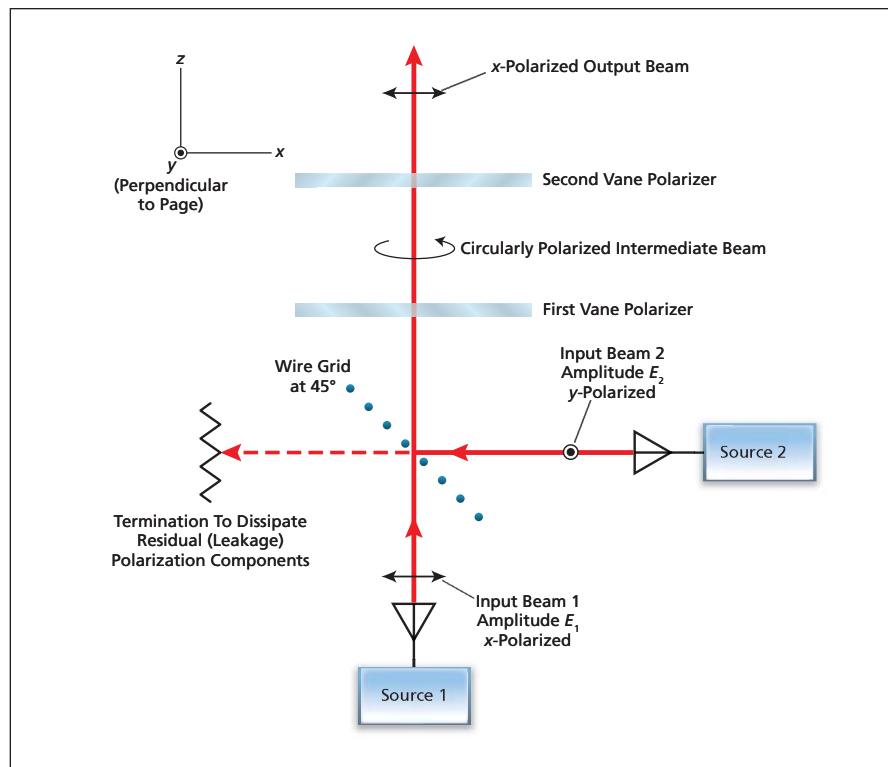
Wire grids are the key quasi-optical elements in many prior equal-power combiners. In somewhat oversimplified terms, a wire grid reflects an incident beam having an electric field parallel to the wires and passes an incident beam having an electric field perpendicular to the wires. In a typical prior equal-power combining scheme, one provides for two properly phased, equal-amplitude signals having mutually perpendicular linear polarizations to impinge from two mutually perpendicular directions on a wire grid in a plane oriented at an angle of  $45^\circ$  with respect to both beam axes. The wires in the grid are oriented to pass one of the incident beams straight through onto the output path and to reflect the other incident beam onto the

output path along with the first-mentioned beam.

In the ideal case, the output beam contains the sum of the input beam powers and has linear polarization at an angle of  $45^\circ$  with respect to either of the input polarizations. Although ordinarily used to combine input signals of equal amplitude, this scheme still works when the amplitudes are unequal, except that undesirably, the output polarization is not fixed at  $45^\circ$ ; instead, the angle of the output polarization, relative to the polarization of input signal 1, is given by  $\arctan(E_1/E_2)$ , where  $E_1$  and  $E_2$  are the electric-field amplitudes of the first and second input signals, respectively. According to the scheme now proposed, one would use a wire-grid combiner as in the equal-power case described above, in combination with two vane polarizers (see figure) that, as described below, would ensure that the output beam had the desired  $45^\circ$  linear polarization.

A vane polarizer (also known as a venetian-blind polarizer) consists of a number of thin metal strips that are parallel to each other. When the electric field of an incident beam is perpendicular to the strips, the field does not induce any electric current in the strips and so the beam passes through the strips, unaffected, in the transverse electromagnetic (TEM) mode. When the electric field is parallel to the strips, the beam is forced into the first transverse electric ( $TE_1$ ) mode, which has a wavelength longer than that of the TEM mode. The thickness of the vane polarizer is chosen so that the TEM mode is delayed by a phase difference of  $90^\circ$  more than that of the  $TE_1$  mode. When the incident beam is polarized at  $45^\circ$  to the vanes, the beam is split into two equal components, one of which is delayed by  $90^\circ$  relative to the other. Upon recombination of the components at the output, the resultant beam is circularly polarized. Conversely, when the incident beam is circularly polarized, the output beam is linearly polarized at  $45^\circ$ .

In the proposed scheme, the two vane polarizers would be placed in the output



**Power From Two Input Beams** of possibly unequal amplitude would be combined with minimal loss, provided that the input beams were properly phased and polarized and the vane polarizers were properly positioned and oriented.

path of the wire-grid combiner. The first vane polarizer would be oriented with its vanes at  $45^\circ$  with respect to the polarization of the combined input beam, so that the output of the first vane polarizer would be circularly polarized. The second vane polarizer would convert the circular polarization to linear and would be oriented to place the final output polarization at a desired, standard angle. Fixing the polarization at a standard

angle would facilitate the assembly of multiple stages to combine power from more than two sources.

Proper phasing is essential to the success of the proposed scheme. The phasing problem is somewhat more complex than in the case of a simple equal-power combiner because propagation through and between the vane polarizers introduces additional phase shift. However, this is not a serious problem because the

majority of the phase shift is a predictable function of the positions and orientations of the vane polarizers, and each power-combining stage could be designed to incorporate an adjustable phase shifter for fine-tuning. There is also an analog of this combining technique in waveguide.

*This work was done by Bruce Conroy and Daniel Hoppe of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44532*

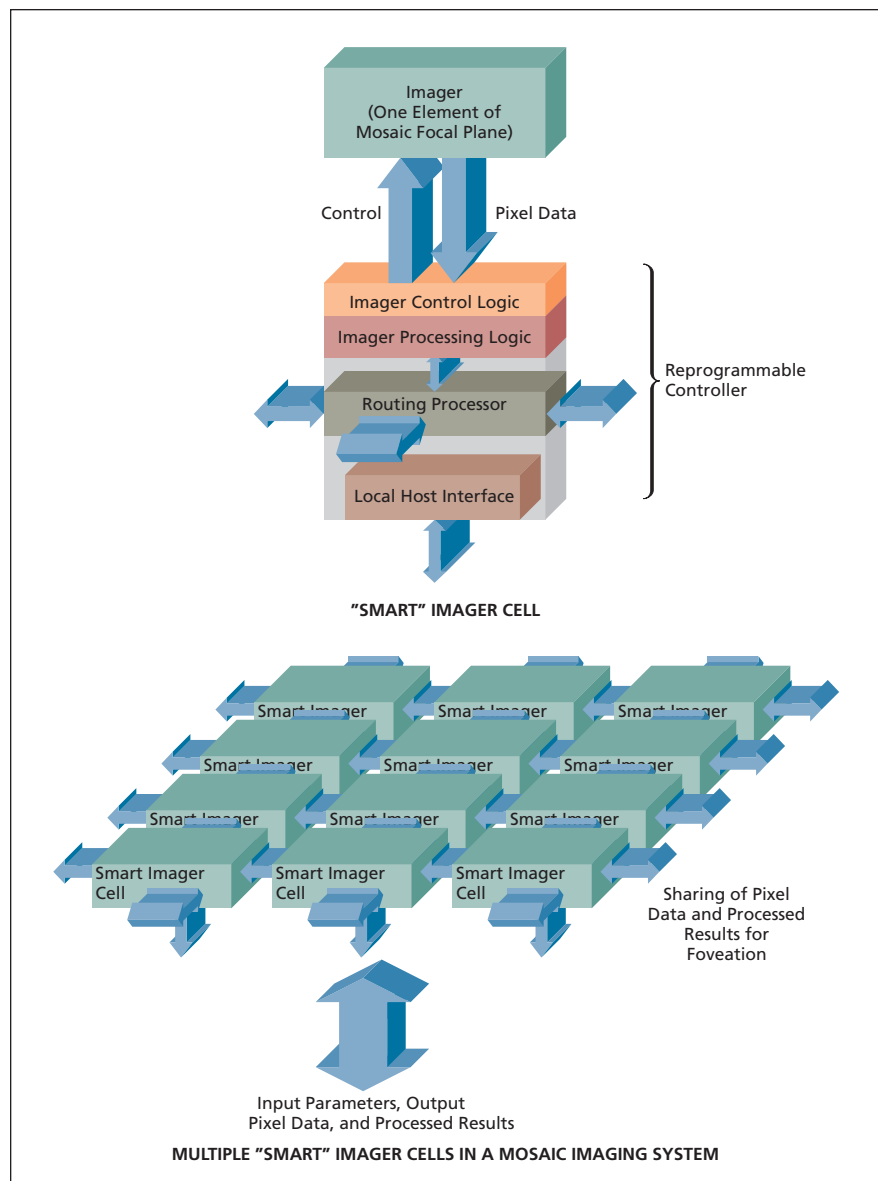
## Synthetic Foveal Imaging Technology

**Gigapixel images are analyzed in real time using multiple foveae.**

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Synthetic Foveal imaging Technology (SyFT) is an emerging discipline of image capture and image-data processing that offers the prospect of greatly increased capabilities for real-time processing of large, high-resolution images (including mosaic images) for such purposes as automated recognition and tracking of moving objects of interest. SyFT offers a solution to the image-data-processing problem arising from the proposed development of gigapixel mosaic focal-plane image-detector assemblies for very wide field-of-view imaging with high resolution for detecting and tracking sparse objects or events within narrow subfields of view. In order to identify and track the objects or events without the means of dynamic adaptation to be afforded by SyFT, it would be necessary to post-process data from an image-data space consisting of terabytes of data. Such post-processing would be time-consuming and, as a consequence, could result in missing significant events that could not be observed at all due to the time evolution of such events or could not be observed at required levels of fidelity without such real-time adaptations as adjusting focal-plane operating conditions or aiming of the focal plane in different directions to track such events.

The basic concept of foveal imaging is straightforward: In imitation of a natural eye, a foveal-vision image sensor is designed to offer higher resolution in a small region of interest (ROI) within its field of view. Foveal vision reduces the amount of unwanted information that must be transferred from the image sensor to external image-data-processing circuitry. The aforementioned basic concept is not new in itself; indeed, image sensors based on these concepts have been described in several



A Mosaic Imaging System According to SyFT would be built from "smart" imager cells, each of which would contain a focal-plane image sensor and a reprogrammable controller.